

Informational Leaflet 93

A PRELIMINARY STUDY OF KING CRAB (Paralithodes camtschatica) OCEAN REPRODUCTION AND THE DELINEATION OF THE KODIAK DISTRICT CONTINENTAL SHELF ENVIRONMENTAL ZONES

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February 6, 1967

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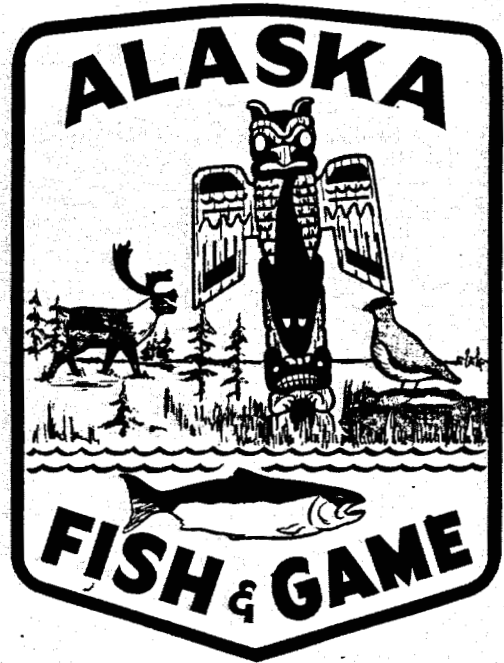


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REPRODUCTION AND THE DELINEATION OF THE KODIAK DISTRICT CONTI-
NENTAL SHELF ENVIRONMENTAL ZONES ^{1/}

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INTRODUCTION

King crab landings at Kodiak have increased from 3 million raw pounds in 1955-1956 (Gray, et. al., 1965) to 75 million pounds in 1965 (Commercial Fisheries Review, 1966).

King crabs follow yearly migration patterns. In late winter they travel to waters of less than 40 fathoms on their breeding migrations (Marukawa, 1933; Powell, 1964). The inshore areas of the Kodiak-Afognak Island group provide a suitable environment, wherein molting and breeding take place (Wallace, et. al, 1949; Powell and Nickerson, 1965). Males precede females to shallow water. After females arrive on the breeding grounds, the males select their breeding partners. They remain with them throughout the females' ecdysis, at which time ovulation and fertilization occur. After breeding, king crabs gradually migrate to deeper water.

Since king crabs utilize inshore shallows for breeding, it is probable that they may simultaneously occupy the shallows of ocean areas as well. This hypothesis has been supported by the results of a joint tagging program conducted by the Alaska Department of Fish and Game and the U.S. Bureau of Commercial Fisheries. Mature king crabs were tagged in the deep (50-100 fathoms) areas offshore from Cape Chiniak and Marmot Island during the summer of 1962 (Powell and Reynolds, 1965). During the following winter and into the early breeding season tagged crabs were recaptured from the shoreward part of Albatross Bank, 20 miles offshore. Ocean breeding was, therefore, indicated.

Presently, foreign trawl fleets are harvesting numerous marine fishes of the continental shelf adjacent to Kodiak Island. Since these fleets operate beyond the proposed 12 mile limit they will undoubtedly continue their harvest

^{1/} This investigation was conducted with Federal-Aid under the Commercial Fisheries Research and Development Act of 1964 (P.L. 88-309).

in the years to come. An expanding domestic fleet is also utilizing these offshore areas. It is feared that an unregulated ocean area fishery, may at certain times of the year be detrimental to king crab populations, especially if breeding stocks exist in these areas.

Knowledge of king crab reproduction in ocean areas of the Kodiak region will enhance the scientific management of the developing fishery. A five year king crab ocean reproduction study was designed to meet this end. The objectives of the first year's (1965-1966) study were: (Phase 1) - determine a suitable method for capturing relatively sedentary, non-feeding, molting, and breeding king crabs on ocean banks; and (Phase 2) - delineate the environmental zones of the continental shelf adjacent to the Kodiak-Afognak Island group so that relationships between breeding areas and specific environmental zones could be evaluated.

The Alaska Department of Fish and Game has, for sometime, been collecting data which will serve to enhance the success of this program. Descriptions of Kodiak district ocean zones as statistical fishing areas, king crab populations and fishing effort and success will be printed as a forthcoming Informational Leaflet.

PHASE 1. BREEDING CRAB OFFSHORE CAPTURE STUDY

Methods

Vessel charter: The 76-foot trawler-crabber "Totem" was chartered for a period of 33 days beginning April 10, 1966. Loran, a 48 mile range radar for position plotting, and a recording fathometer for the determination of depth and bottom characteristics were available aboard the "Totem". The captain and crew possessed several years' experience in trawling for king crabs and shrimp.

Study area: Portlock Bank, lying 55 miles northeast of Kodiak and extending from 30-85 miles seaward was selected as the study region. Fishing upon Portlock is difficult because of characteristic hard rocky substrate, severe ocean currents and lack of local fishing experience under these conditions. Crab pots, otter trawls and tanglenets were selected as the methods of sampling since they are all extensively used in the commercial exploitation of king crabs. The tanglenets were not delivered until after the field work was completed so comparisons of tanglenet selectivity with pots and trawls was not possible.

Sampling: Portlock Bank was divided into four sections on the basis of position and distance from shore (Figure 1). Two sections were termed interior and two exterior. Further subdivision into 2.5 mile square grids resulted in sections I-IV containing 41, 21, 43, and 13 areas, respectively. Those grids

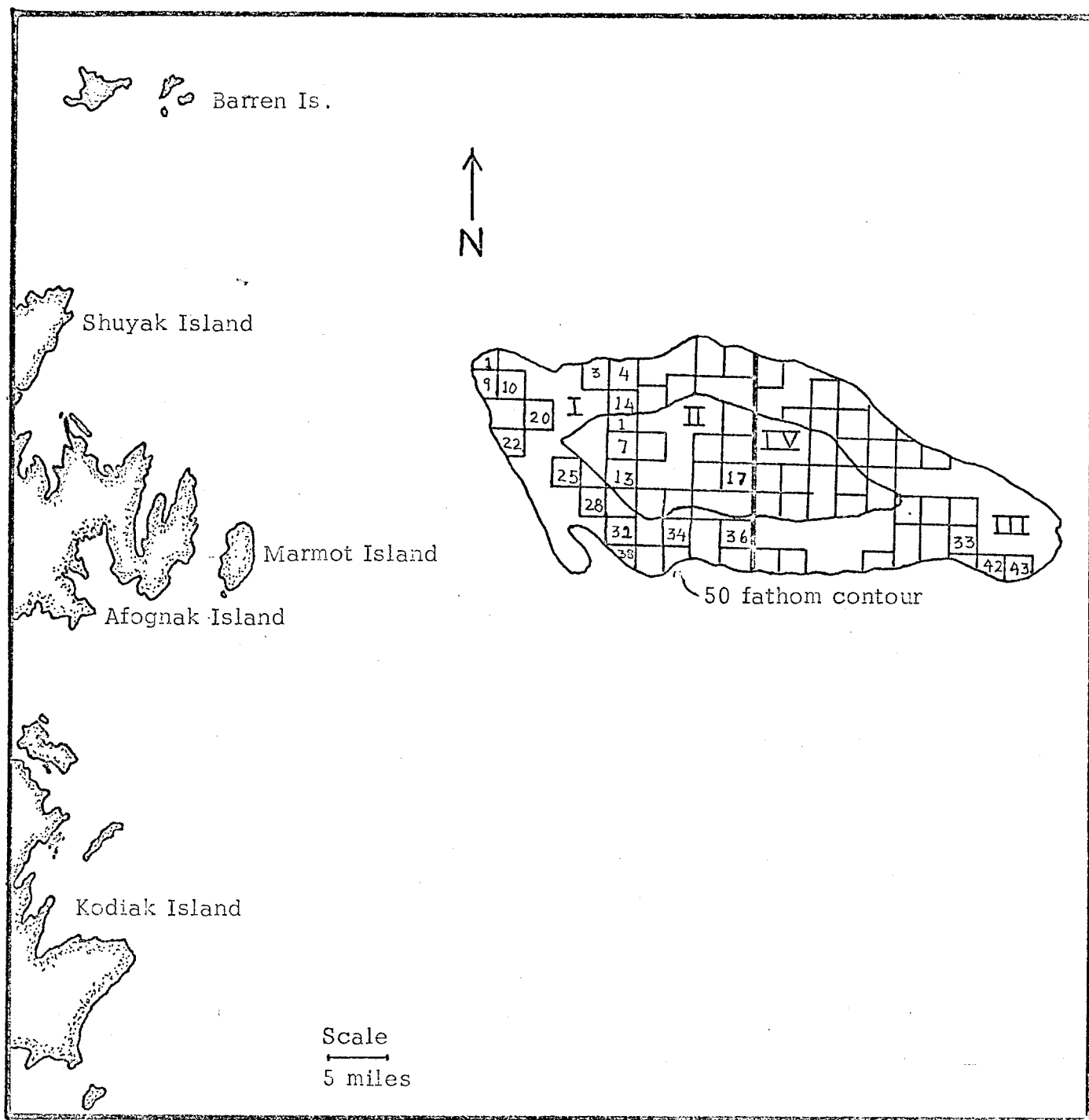


Figure 1. Location of randomly drawn study areas and designation of stations sampled on Portlock Bank, 1966.

which were to become study areas were selected separately within each station and at random in proportion to size of sections. Sixty trawling areas were selected in groups of 20, 10, 23 and 7 for sections I-IV, respectively. In addition, 14 pot fishing areas were randomly drawn from the groups of trawling areas. Sections I-IV contained 5, 2, 5 and 2 pot study areas, respectively.

Trawling: Standard eastern-type otter trawls, with 71 foot head ropes and 3.5 inch mesh web throughout were used. Each tow traversed the 2.5 mile square study area. In study areas sampled with both pots and trawls, fishing was conducted adjacent to the pot string for comparison of sampling methods. Distance of tows was determined by setting a fixed radar buoy and working from that point.

Pot fishing methods: Ten pots, baited with fresh fish were strung in straight, 2 mile lines. The 8' x 8' pots were soaked for 2 days in each of the pot fishing areas. Each pot weighed from 700-800 pounds and had attached to it a 100 fathom line and two 16-inch diameter buoys. The lines were extra long to prevent the buoys from being dragged down by strong tidal currents.

Trawling success: Sixty-seven percent (22 of 33 days) of the charter interval was interrupted by severe weather. However, twenty tows were completed in as many study areas. Trawling depths ranged from 29-50 fathoms on predominantly rock and shell bottom. Trawling effort by station is presented in Table 1. The most successful tow captured 1,477 king crabs (171 males and 1,306 females), and the least successful tow was brought aboard empty. A total of 3,181 crabs (1,029 males and 2,152 females) were captured by trawls for an average of 159 crabs per tow. Males constituted 32 percent of the catch and ranged from 79-218 mm in carapace length (Table 2). Females comprised 68 percent and ranged from 80-187 mm in length. Of the 1,029 males, 622 (60%) had molted in 1966 and were new-shell. The remaining 407 failed to molt in 1966 and were either biennial or triennial molters (anexuvians).

Of the 2,152 trawl caught females, 686 (32%) were new-shell and 1,466 (68%) were old-shell crabs preparing to molt. Five hundred-seventy two (83%) of the new-shell females had ovulated recently and bore a clutch of new eggs. Ninety-seven percent, or 1,430 of the old-shell females possessed eyed eggs that had not yet hatched. The eggs of the remaining 3 percent had hatched as evidenced by the presence of empty egg shells on the swimmerets.

Nine grasping king crab pairs were captured by trawling. Males continued to grasp their female partners after removal from the trawl.

In addition to grasping pairs approximately 75 shed exoskeletons were taken in six tows. The exoskeletons were broken to the extent that sex could not be determined.

Table 1. Number of king crabs captured on Portlock Bank, Kodiak Island area, spring of 1966.

Date 1966	Sampling station	Depth fathoms	Bottom type	Distance trawled miles	Direction of tow or pot string	King crab taken		Pots fished number	King crabs taken pot fishing	
						trawling females	males		females	males
4/15	I-1	41-45	Soft	2.5	ESE	26	71	--	--	--
4/15	I-10	35-37	Hard	2.5	E	55	227	--	--	--
4/15	I-20	32-35	Hard	2.5	SSE	30	62	--	--	--
4/19	I-1	41-45	Soft	---	ESE	--	--	9+	12	459
4/20	I-22	34-39	Hard	2.5	NNW	1306	171	10	13	41
4/21	I-25	35-45	Hard	2.5	SE	11	12	--	--	--
4/21	I-28	33-38	Hard	2.5	WNW	315	203	10	47	268
4/24	III-33	30-34	Sh, Rk	0.4*	NNW	0	0	--	--	--
4/24	III-42	37-38	Sh, Rk	1.0*	S	0	0	--	--	--
4/24	III-43	44-48	Sh, Rk	2.0	WSW	0	0	--	--	--
5/ 3	I-14	40-42	Sh, Rk	2.0	SSE	5	19	--	--	--
5/ 3	I-4	42-44	Hard	2.0	WSW	28	17	--	--	--
5/ 3	I-3	42-50	Hard	2.0	SSE	16	9	10	--	31
5/ 3	II-1	39-40	Sh, Rk	2.0	SSE	8	17	--	--	--
5/ 3	II-7	37	Hard	2.0	SSE	39	37	--	--	--
5/ 5	I-36	37-41	Hard	2.0	ESE	9	30	10	0	31
5/ 9	I-9	42-44	Hd, Sh	1.5*	WNW	164	45	--	--	--
5/10	II-13	37	Hd, Sh	2.0	WSW	11	19	--	--	--
5/10	I-32	35-39	Hd, Sh	2.0	WSW	8	21	--	--	--
5/12	II-17	29-33	Hard	2.0	SE	23	37	10	0	8
5/12	I-34	34-37	Hd, Sh	2.0	NNW	43	32	--	--	--
5/12	I-38	37	Hard++	---	---	--	--	--	--	--
Total crabs by sex						2152	1029	59	72	838
Total crabs						3,181		910		

* Incomplete trawl due to rough bottom.

+ The door of one pot was open when retrieved.

++ Parted main cable at beginning of tow.

Table 2. Length frequency of 3,181 trawl caught king crabs by age of exoskeleton, Portlock Bank - Kodiak Island, 1966.

Carapace length mm	Age of exoskeleton since last molt						Total crab
	Females				Males		
	1-month		12-month		1 month	12 months	
	new eggs	no eggs	eyed eggs	no eggs			
75-79	--	--	--	--	1	--	1
80-84	--	2	--	--	5	--	7
85-89	--	2	--	--	6	--	8
90-94	2	3	--	--	3	--	8
95-99	--	12	--	1	5	--	18
100-104	8	25	--	--	20	--	53
105-109	37	29	1	--	25	--	92
110-114	57	23	6	2	43	--	131
115-119	76	12	9	1	44	--	142
120-124	77	3	32	1	38	--	151
125-129	46	--	105	1	38	--	190
130-134	38	2	226	2	37	--	305
135-139	86	1	306	7	44	--	444
140-144	62	--	228	4	32	--	326
145-149	45	--	140	3	33	--	221
150-154	24	--	117	3	26	--	170
155-159	9	--	98	1	28	--	136
160-164	4	--	82	6	23	5	120
165-169	--	--	31	--	26	19	76
170-174	1	--	26	1	21	32	81
175-179	--	--	9	2	40	56	107
180-184	--	--	11	--	21	74	106
185-189	--	--	3	1	24	90	118
190-194	--	--	--	--	24	59	83
195-199	--	--	--	--	8	42	50
200-204	--	--	--	--	7	21	28
205-209	--	--	--	--	--	8	8
210-214	--	--	--	--	--	--	--
215-219	--	--	--	--	--	1	1
column totals	572	114	1,430	36	622	407	
sub-totals	686		1,466		1,029		3,181
ovigerous females	83%		98%				

Pot fishing results: Six of the 14 pot fishing areas were sampled. Soak times ranged from 2-8 days, and was weather regulated. Nine hundred and ten king crabs (838 males and 72 females) were caught in 60 pots, for an average catch of 15 crabs per pot without regard to soak time. Males comprised 92 percent of the catch and ranged from 100-204 mm in carapace length. Females ranged from 90-185 mm and comprised 8 percent of the catch (Table 3).

A total of 673 (74%) of the males had molted in 1966 and 215 (26%) were skip-molts. Sixty-six females (92%) were new-shell and 6 (8%) old-shell, but unlike males were approaching ecdysis. Fifty-six (85%) of the new-shell females were ovigerous. The other 10 new-shell females were immature. Fully developed eggs were present on 5 (83%) of the old-shell females, and the eggs of one (17%) were hatched.

Comparison of trawl and pot fishing: A trawl was towed along each string of pots. The selectivity of the two types of gear was compared in this way (Table 4). The six tows caught 2,221 crabs and the strings of pots captured 910 crabs, for averages of 370 and 152 crabs, respectively. The trawls caught 571 males and 1,700 females, while the pots caught 838 males and 72 females. Exoskeletons of trawl caught new-shell crabs were often very soft, whereas those taken in pots were firm.

Discussion

A chartered vessel lifted 60 pots and conducted 20 tows on Portlock Bank. A total of 4,091 king crabs were captured on the eleven days that weather permitted the vessel to fish. Failure to complete the proposed sampling schedule was directly related to the size of the vessel employed. In future years it is hoped that a vessel more capable of fishing shallow ocean areas can be chartered. Trawling on Portlock Bank is particularly inefficient because the substrate is composed of shell, rock and boulders. Trawls were severely torn during 5 of the 20 tows, and ripped to lesser degrees on numerous other tows. The catch would probably have been greater if the trawls were not ripped and torn.

Capture of nine grasping pairs of king crabs strongly indicated that king crabs breed on Portlock Bank. Additional grasping pairs may have been captured that were not discernable because they separated before being taken aboard. Male graspers are not believed to migrate long distances while carrying their mates. Consequently grasping occurs on or near the breeding grounds.

Further evidence that Portlock Bank served as a breeding area was the capture of numerous soft new-shell females which characteristically molt while being grasped and breed immediately thereafter. As a result, the female molting grounds serve also as breeding grounds. Trawl collections of numerous females

Table 3. Length distribution of 910 pot-caught king crabs by age of exoskeleton, Portlock Bank - Kodiak Island, 1966.

Carapace length mm	Age of exoskeleton since last molt						Total crab
	Females				Males		
	1-month		12-month				
	new eggs	no eggs	eyed eggs	no eggs	1 month	12 months	
90-94	--	1	--	--	--	--	1
95-99	--	--	--	--	--	--	--
100-104	1	5	--	--	6	--	12
105-109	3	--	--	--	3	--	6
110-114	5	3	--	--	19	--	27
115-119	7	1	--	--	8	--	16
120-124	18	--	--	--	24	--	42
125-129	9	--	--	--	48	--	57
130-134	8	--	1	--	60	--	69
135-139	5	--	1	--	70	--	76
140-144	--	--	--	--	76	--	76
145-149	--	--	1	--	63	2	66
150-154	--	--	--	--	38	2	40
155-159	--	--	--	--	24	12	36
160-164	--	--	--	--	40	15	55
165-169	--	--	--	--	36	36	72
170-174	--	--	1	--	30	35	66
175-179	--	--	--	--	22	52	74
180-184	--	--	--	--	31	28	59
185-189	--	--	1	1	14	21	37
190-194	--	--	--	--	8	8	16
195-199	--	--	--	--	3	3	6
200-204	--	--	--	--	--	1	1
column totals	56	10	5	1	623	215	
sub-totals		66		6		838	910
ovigerous females		85%		83%			

Table 4. Comparison between catches of king crab trawling and pot fishing,
Portlock Bank - Kodiak Island, 1966.

Station	<u>Trawling alongside pot string</u>				<u>Pot string</u>			
	<u>Male</u>		<u>Female</u>		<u>Male</u>		<u>Female</u>	
	number	percent	number	percent	number	percent	number	percent
I-1	71	73	26	27	459	97	12	3
I-3	9	75	16	25	31	100	0	0
I-22	171	12	1,306	88	41	76	13	24
I-28	203	39	315	61	268	85	47	15
I-36	30	77	9	23	31	100	0	0
II-17	37	57	28	43	8	100	0	0
Subtotals	521		1,700		838		72	
Totals		2,221				910		
Average crabs per station		370				152		

approaching ecdysis and shed exoskeletons provided still further support that king crabs were molting and breeding on the ocean shallows of Portlock Bank.

Many adult males, both new-shell and anexuvians, were captured in the study areas. Since both exuviant and anexuviant males breed (Powell and Nickerson, 1965), catches indicated that a possible brood stock of males was present on Portlock Bank during the 1966 breeding season.

A mathematical analysis of the relative effectiveness of trawls and pots would be premature at this time, because of inadequate sample size. Trawling was completed in one-third of the proposed areas and not quite half the pot fishing areas were sampled.

Variability of crab density within sections I-IV is also unavailable for the same reason. No trawling was conducted in Section IV, and the three tows made in Section III were all on the offshore edge of the bank and were brought aboard empty. Pots were fished only in Sections I and II.

In spite of the small number of samples collected, subjective comparisons between pot and trawl fishing could be made. Trawling appeared superior to pot fishing for capture of molting and breeding crabs. Grasping pairs and soft females were captured only in trawls and pre-molt females were proportionately more abundant in trawls. In addition, trawls collected shed exoskeletons that were not obtainable with pots. Since breeding crabs are relatively sedentary, mobile fishing gear seems more efficient for their capture.

PHASE 2. DELINEATION OF CONTINENTAL SHELF ENVIRONMENTAL ZONES

Methods

The continental shelf adjacent to Kodiak Island was originally sub-divided into general environmental zones according to depth by Powell (1965). Later, Simon (et al., 1966) described the zones according to geographical location. These zones will be further sub-divided into niches according to bottom types as time permits. Reports providing data of incidentally captured crabs by the U.S. Bureau of Commercial Fisheries and International Pacific Halibut Commission have been requested. Additional correspondence was written where appropriate, and initial receipts of data analyzed.

Results

King crab fishing grounds in the Kodiak Island area consist of 21,891 square miles of the continental shelf to a depth of 150 fathoms (Table 5). Of

Table 5. Delineation of the continental shelf environmental zones, Kodiak Island area, by depth, area and geographical location.

Zone designation	Description ^{1/}	Depth fathoms	Area square miles	Percent of total area
Shaded	inshore-shallow	0-50	746	3.4
1	inshore-shallow and deep	0-50	1,731	7.9
2	nearshore-shallow	0-50	2,352	10.7
3	nearshore-deep	51-100	2,838	13.0
4	ocean-deep	51-100	5,419	24.8
5	ocean-shallow	0-50	5,030	23.0
6	ocean-very deep	101-150	3,775	17.2
Total			21,891	100.0

^{1/} Inshore, primarily within bays; nearshore, within 30 miles of shore; ocean, more than 30 miles from shore.

this, 7,382 square miles (34%) are classed as nearshore or ocean shallows (Figure 2), and may be considered as potential king crab breeding grounds. The ocean breeding area consisted of 5,030 square miles, or 23% of the total, and nearshore shallows are 2,352 square miles (11%) in area.

Discussion

General environmental areas of the Kodiak continental shelf have been outlined. Continuing efforts will be made to determine if breeding crabs concentrate in specific niches of the ecological zones.

Distribution and relative densities of king crabs in the Kodiak area continental shelf environmental zones should be further studied. Specific ocean breeding areas should be cataloged and a determination made of their relative importance in the overall picture of Kodiak area king crab reproduction.

It is feasible that in future years these ocean breeding areas may be closed to foreign trawlers during the king crab breeding season.

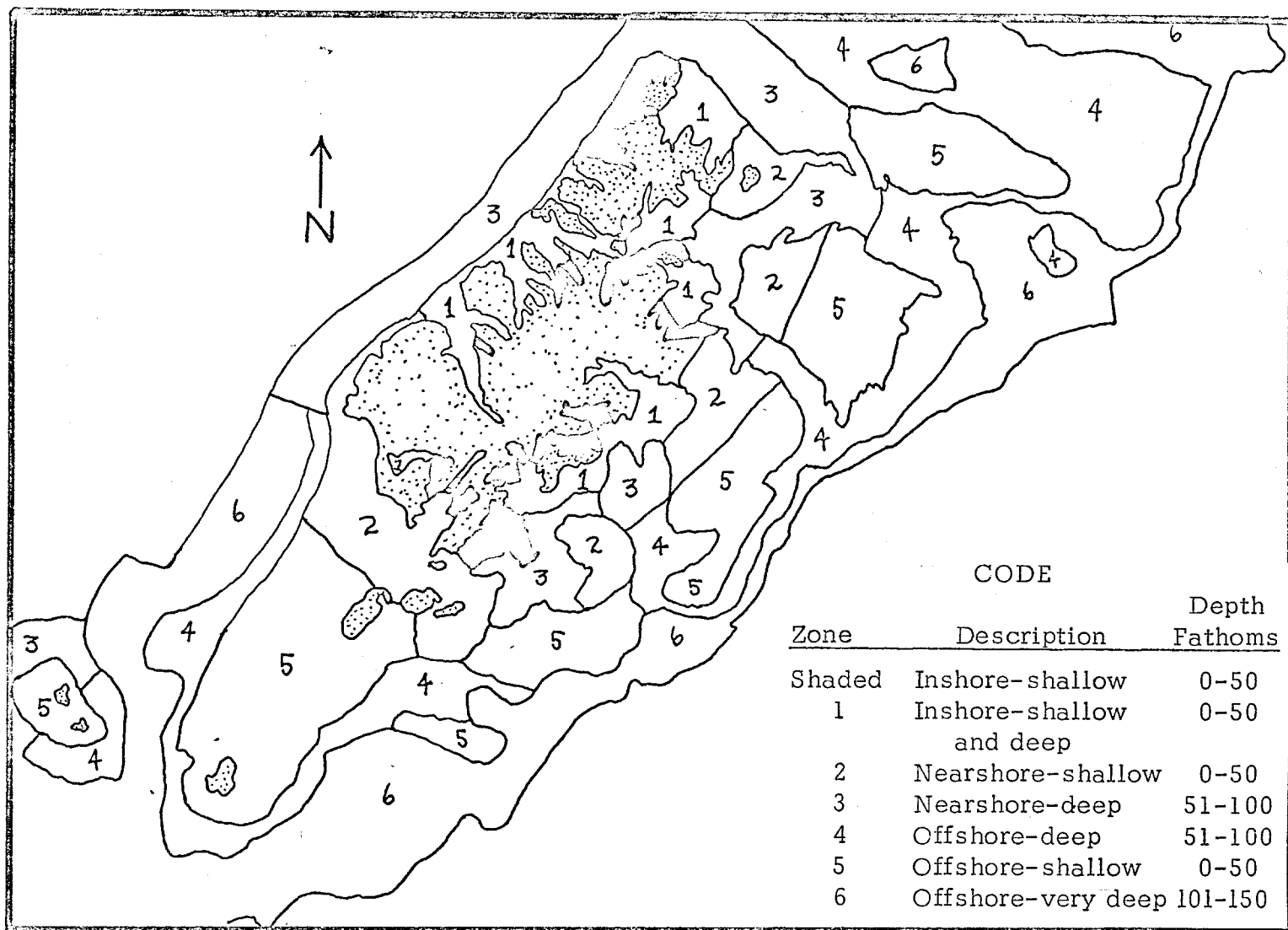


Figure 2. Continental shelf environmental depth zones, Kodiak Island area.

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